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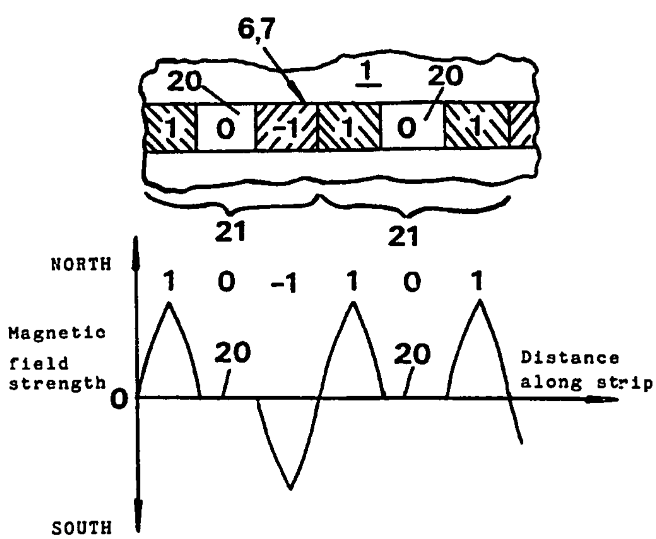

(57) Abstract

A magnetic token (1) bears a stripe (6, 7) incorporating a magnetic data recording medium of high coercivity having region (1 and -1) which are magnetised and separated by unmagnetised (0) regions (20). The sequences 1, 0, -1 and 1, 0, 1 define a magnetic fuse (21) which can be removed by magnetising the unmagnetised (1) region (20). The magnetic fuses (21) can either be used as a direct measure of the unexpired units on the token (1) or recorded in a read/write strip (8). Once a magnetic fuse (21) has been removed , any fraudulent attempt to "refresh" the token by demagnetising region (20) to its former unmagnetised state is frustrated due to the hysteresis of the magnetic recording medium.

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MAGNETIC TOKEN AND TOKEN TRANSACTION SYSTEM

This invention relates to a magnetic token particularly, but not exclusively, for use with telephones equipped with a transaction apparatus having means, such as magnetic token read/write unit, for reading magnetic data carried by the token and for writing magnetic data onto the token. The invention also relates to a token transaction system comprising a plurality of such magnetic tokens and such transaction apparatus.

Formerly such magnetic tokens have been made from plastics material configured as a card bearing one or more strips loaded with high coercivity magnetic material. Such strip or strips are typically arranged to provide a number of areas having distinct functions. For instance, some areas are dedicated to the provision of read-only memory and others to the provision of read/write memory.

Irrespective of its function, each area is usually magnetised, during manufacture of the token, to hold an appropriate magnetic code. A code held by a read-only area is typically used to interface the token with a read/write unit by opening ports in the read/write unit, and provides a

code for verifying that the token is bona fide. A code held by a read/write area is usually a binary number representing the value of a "full" token. As the token is used, this number is updated by the read/write unit writing a new binary number representing the value remaining on the token after use.

Such tokens have proved vulnerable to fraud as it has been possible for criminals, in various ways, to record the information held on a token before it is used, and then to re-record this information on a used token to replenish its value.

According to one aspect of the invention a magnetic token bears a magnetic data recording medium defining at least one magnetic fuse comprising an unmagnetised region adjacent a magnetised region whereby the magnetic fuse can be removed by subsequent magnetisation of the unmagnetised region. In this manner, once the unmagnetised region has been magnetised, it is extremely difficult to restore it to the original unmagnetised condition and consequently fraudulent alteration is frustrated. This is particular so when the magnetic recording medium is of high coercivity. By removing the magnetic fuses and detecting the number and/or sequence of the fuses removed, it is possible to

verify the amount of use of the card. Because of the property of hysteresis, once a magnetic material has been magnetised it is difficult to return it to an unmagnetised state. Therefore by magnetising unmagnetised regions it is possible to record use of the token on the token and it is difficult to refresh the card illegally.

Preferably the magnetic data recording medium defines a plurality of magnetic fuses each comprising an unmagnetised region adjacent a magnetised region whereby each magnetic fuse can be individually removed by subsequent magnetisation of its unmagnetised region.

The magnetic data recording medium preferably defines a stripe along the major axis of the token and the magnetic fuses are arranged sequentially along the stripe. The magnetic data recording medium may also define a read/write area bearing data representing the current value of the token. The read/write area is preferably separated from the magnetic fuses by a non-magnetised area. Alternatively the non-magnetised area may be defined by a transverse interruption of the stripe.

At least one magnetic fuse is preferably defined by a pattern of at least three regions which are either

magnetised or unmagnetised, and this magnetic fuse can be removed by subsequent magnetisation of at least one unmagnetised region. At least one of these magnetic fuses may be defined by at least one unmagnetised region and two magnetised regions of opposite polarity.

According to another aspect of the invention a token transaction system comprises a plurality of such magnetic tokens and a transaction apparatus which includes means for reading magnetic data carried by each token representing its value, and means for selectively magnetising unmagnetised regions to remove magnetic fuses dependant on the decremented value of the token.

The transaction apparatus may also include means for rejecting any token having less than a predetermined number of unmagnetised regions.

Each magnetic fuse may represent a predetermined fraction of the original value of the token recorded by data in a read/write area of the token, the transaction apparatus including means for updating such data in the read/write area in response to each change in value of the token arising from use, and the means for selectively magnetising each unmagnetised region being arranged to remove a magnetic

fuse whenever the value of the token decreases by an amount equivalent to said predetermined fraction. In this manner the read/write area may be updated with the revised, or decremented, value of the token so that this data can be compared with the number, or notional value, of the magnetic fuses removed or remaining. If the decremented value of the token does not tally with the number, or notional value, of the magnetic fuses removed or remaining, the transaction apparatus can then be arranged to reject the token thereby providing further protection against fraud. Conveniently, the updating of data in the read/write area is made in response to a change in value of the token arising from use. The token may be used for payment of a service, for example a telephone call, a road toll, a bridge toll, use of a car park, or for payment for a product from a vending machine. It is also possible that the token may be used in applications where there is no financial transaction, for instance as a pass permitting a limited number of entries through a security gate. Preferably there are ten magnetic fuses in each token and each magnetic fuse represents one tenth of the original value of the token. For instance, a token carrying a full value of 100 units would have a magnetic fuse removed in response to every ten units used. This would mean that a token used for say 45 units would have four magentic fuses removed indicating that the token

had been used for at least 40% of its full value. The code carried on the read/write area would show that only 55 units remained. A criminal trying to reduce the recorded use, by re-writing the read/write area, would only be able to increase the value by 5 units without invalidating the balance on the card. Alternatively each magnetic fuse may represent a different fraction of the original value of the token.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a plan view of a magnetic token in accordance with the invention;

Figure 2 is a diagrammatic vertical section through a token transaction system, in accordance with the invention, comprising a telephone transaction apparatus and a magnetic token;

Figure 3 is an enlarged plan view of part of the token shown in Figure 1 showing the magnetisation of part of a stripe bearing read only information against a graph of the magnetic field strength;

Figure 4 is a graph of the magnetic field strength along a read/write stripe; and

Figure 5 is a typical hysteresis loop for a magnetic material.

With reference to Figures 1 and 2, a magnetic token 1 is made from a sheet of plastics material configured as a card bearing magnetic stripes 2, 3, 4, 5, 6, 7 and 8 loaded with magnetic material constituting a magnetic data recording medium.

The corner stripes 2, 3, 4 and 5 are provided for opening a port 9 in a telephone transaction apparatus 10 to permit full insertion of the token 1 and also to alert the transaction apparatus 10 to the presence of the token. Only the corner stripes 2 and 3, or 4 and 5, at the end of the token presented into the port 9 are detected by the conventional magnetic detector means 11 adjacent the port. If desired, the corner stripes 2 and 5 and the corner stripes 3 and 4 could be formed by the ends of respective continuous stripes extending along the major edges 12 and 13 of the token 1. Although both corners 2 and 3, or 4 and 5, are normally used to open the port 9, this could be achieved

by using only one corner or another portion of the minor edge 14 and 15 of the token. The stripes 6, 7 and 8 are loaded with a high coercivity magnetic material and are aligned, as shown, along the major axis 16. The stripes 6, 7 and 8 are separated by transverse interruptions 17 as shown. However the stripes 6, 7 and 8 could be portions of a continuous stripe along the major axis 16 separated by non-magnetised zones in the general position of interuptions 17.

The stripes 6 and 7 define areas which are, except as hereinafter described, for read-only memory (Rom) and these are magnetised during manufacture to carry a code which can be read by a unit 18 for reading magnetic data to verify the validity of the token. A linear scan of stripe 6 or 7 by the read unit 18 would typically produce an output as shown in Figure 3. As shown, this output is a series of peaks and troughs of magnetism, those above the line being of opposite polarity to those below the line. These peaks and/or troughs are, in accordance with the present invention, separated by unmagnetised regions 20 which have zero magnetism. The peaks represent magnetised regions of the stripes 6 or 7 having one magnetic polarity given the notation "1", the troughs represent magnetised regions having the opposite magnetic polarity given the notation

"-1", and the unmagnetised regions are given the notation "0". This notation could be considered (if the notation "1" is counted as the same as "-1") as a binary code, and the number represented in Figure 3 being 101101 binary which would be part of the number held by all bona fide unused tokens. It will thus be noted that the stripe 6 and/or 7 is magnetised to bear a series of zeros bounded by ones. Each sequence 21, the first two of which are, for example, "1, 0, -1" and "1, 0, 1" in Figure 3 forms a "magnetic fuse", the function of which will be described later. Although only two magnetic fuses 21 are shown in Figure 3, the stripe 6 and/or 7 would typically have ten of such magnetic fuses arranged in series along the major axis 16 of the token, each magnetic fuse 21 representing 10% of the token's initial value.

Stripe 8 is a read/write area which carries a code representing the number of units remaining on the token 1. When the token is purchased, this code will represent the full value of the token but, as it is used, the token is updated by a read/write unit 22 comprising the read unit 18 and a write unit 23 to decrement those units used. A scan of the stripe 8 by the read unit 18 would typically produce an output as shown in Figure 4. The output is passed to a Schmitt trigger circuit which, in response, produces the

waveform as shown by the broken lines. The difference in width of this waveform is dependent upon the variation in the pitch of the original output and it carries the binary code representing the number of units remaining on the token.

Magnetic materials exhibit a property called hysteresis and a typical hysteresis loop, being a plot of magnetism induced in the material by an applied magnetic field, is shown in Figure 5. An unmagnetised region of the stripe 6 or 7 will have the value A in Figure 5 until a magnetic field is applied and the induced magnetism rises towards B. This rise is rapid at first but diminishes as magnetic saturation is approached at B. The magnetic material in the stripe becomes magnetically saturated when an increase in the applied field does not give a corresponding increase in magnetism induced. Thus the rise of magnetism with applied magnetic field is represented by curve A-B in Figure 5. When the applied magnetic field is reduced to zero the induced magnetism falls to a residual non-zero level C, as represented by the curve B-C in Figure 5.

If the polarity of the magnetic field is then reversed and increased to point D, the magnetic material in the

stripe will then have zero induced magnetism, but it is important to note that it is zero in the presence of a specific magnetic field. It should also be noted that at point D the curve C-D is steep, which means that a small error in the applied magnetic field will result in a significant induced magnetism. The reversed magnetic field may be increased further to point E which represents the saturation point of the magnetic material with the reverse polarity to the saturation point B.

If the magnetic field is again reduced to zero, a point F is reached which represents the residual magnetism of the stripe. A condition of zero induced magnetism will again be reached if the polarity of the applied magnetic field is reversed and the magnitude increased to point G. As the curve FG is steep, any small error in the applied field will result in a significant induced magnetism.

It is important to note that once unmagnetised material has been magnetised it is particularly difficult to return it to a state of zero magnetism. In order to do so a very precise magnetic field must be applied, as is shown in Figure 5, at points D and G of the hysteresis loop. When no field is present the material will still be magnetised.

The transaction apparatus 10 shown in Figure 2 is therefore provided with a unit 24 for selectively magnetising the unmagnetised regions "0" thereby selectively removing the magnetic fuses 21. The unit 24 is accordingly able to write only once to each magnetic fuse 21 which effectively is permanently altered due to the difficulty of returning its now magnetised region "0" to the state of no magnetism indicated at A in Figure 5.

The token may be used, for instance, as a pre-payment token for a public telephone. During a telephone call, the number of units used is monitored by the read/write unit 22 of the telephone transaction apparatus 22, and unmagnetised portions of the stripe 7 are magnetised every time 10% of the full value of the token is used. This re-writing alters one sequence 21 with, for example, "1, 1, -1" by magnetising the region "0" that was previously unmagnetised. The exact total number of units remaining on the token is updated on the token by the write unit 23 writing the new number of units on the read/write stripe 8 upon completion of the call.

When the token is next inserted, stripes 6 and/or 7, and 8 will be read and a call allowed only if sufficient magnetic fuses remain to verify the remaining percentage of

unused units in the read/write stripe 8. Once all of the magnetic fuses 21 have been removed, representing 100% of the token having been used, the read/write stripe 8 of the token cannot be simply refreshed by a criminal as it is also necessary to replace the magnetic fuses in the stripe 6 and/or 7. For the latter to be done the criminal would have to know which of the regions need to be unmagnetised and then to unmagnetise each one exactly. This is to all intents impracticable because the sequences recorded on stripe 6 and/or 7 will always have some residual magnetism because of the hysteresis of the magnetic material. If a tampered token is inserted into a transaction apparatus 10, it will be read and the residual magnetism detected. The token will then be rejected as not verifying the units in the read/write stripe 8 and the call not allowed. It would be possible for the token to be partially refreshed between each magnetic fuse, but the value of such a refreshment would not be worthwhile.

The invention thus provides a token and a transaction system whereby a token cannot be easily refreshed by a criminal.

In alternative embodiments of the invention, the sequences or fuses could be used to represent differing

percentages of use, which would further complicate any possible refreshing of the token.

It will be appreciated that whilst the embodiment herein described is in the form of a card, other forms of token are also envisaged.

Although each magnetic fuse 21 has been expressed as a series of three regions of which one is unmagnetised, it could be expressed by two regions "1,0" the "1" or "-1" being used to identify the relative positions of the "0" of successive magnetic fuses. Similarly each magnetic fuse could comprise more than three regions of which more than one could be unmagnetised. The removal of such a magnetic fuse could then be by magnetising one, or some, or all of the unmagnetised regions. When each magnetic fuse 21 has more than one unmagnetised region it could be arranged to be removed by magnetising a selected one of the unmagnetised regions, the selection varying randomly from magnetic fuse to magnetic fuse in a sequence known by the transaction apparatus 22.

Instead of using the magnetic fuses 21 to verify the range of values still unexpanded in the read/write stripe 8, the magnetic fuses 21 may comprise the entire system for

recording and decrementing the value of the token. In this event a separate magnetic fuse would represent each unit by which the token is to be decremented. In this event the magnetic fuses may occupy the whole of a centre stripe extending between the minor edges 14 and 15 of the token, or a series of parallel stripes parallel with the major axis, or be marked in a series of parallel arrays extending along a single central stripe. The write unit 23 would not be required and the read unit 18 would read the number of unexpired units on the token with the magnetising unit 24 removing magnetic fuses 21 as the units are expanded. Verification of the token can be arranged by using different codes either on the same or different stripes. Verification may also be achieved by noting the sequence of polarities "1" and "-1" between adjoining magnetic fuses, or the stronger change of signal between '1" and "-1" rather than the weaker change of signal between "0" and "1" or between "0" and "-1".

Fraudulent refreshing can be further frustrated by varying the coercivity of the magnetic material along a stripe so that the exact field, for returning a previously unmagnetised region to approximately its unmagnetised state, will vary from magnetic fuse to magnetic fuse in a random manner. Provided the read unit 18 is sufficiently

sensitive, even the slightest residual magnetism left in a "refreshed" region that should be totally unmagnetised will be detected. Detection of only a single "refreshed" region will be sufficient to reject the token as having been tampered with.

CLAIMS

1. A magnetic token bearing a magnetic data recording medium defining one or more areas holding a magnetic code, characterised in that the magnetic data recording medium (6, or 7, or 8) also defines at least one magnetic fuse (21) comprising an unmagnetised (o) region (20) adjacent a magnetised region (1 or -1) whereby the magnetic fuse (21) can be removed by subsequent magnetisation of the unmagnetised region (20).

2. A magnetic token as in Claim 1, characterised in that the magnetic data recording medium (6 or 7, or 8) defines a plurality of magnetic fuses (21) each comprising an unmagnetised region (20) adjacent a magnetised region (1 or -1) whereby each magnetic fuse (21) can be individually removed by subsequent magnetisation of its unmagnetised region (o).

3. A magnetic token as in Claim 2 and in which the magnetic data recording medium defines a stripe (6, 7, 8) along the major axis of the token (1), characterised in that the magnetic fuses (21) are arranged sequentially along the stripe (6, or 7, or 8).

4. A magnetic token as in Claim 3 and in which the magnetic data recording medium also defines a read/write area (8) bearing data representing the current value of the token (1), characterised in that the magnetic fuses (21) are arranged sequentially along the stripe (6 or 7).

5. A magnetic token as in any preceding claim, characterised in that at least one magnetic fuse (21) is defined by a pattern of at least three regions which are either magnetised (1 or -1) or unmagnetised (0), and this magnetic fuse (21) can be removed by subsequent magnetisation of at least one unmagnetised region (20).

6. A magnetic token, as in Claim 7, characterised in that at least one magnetic fuse (21) is defined by at least one unmagnetised region (20) and two magnetised regions (1 or -1) of opposite polarity.

7. A token transaction system comprising a plurality of magnetic tokens each bearing a magnetic data recording me dium defining magnetic code areas, and a transaction apparatus which includes means for reading magnetic data carried by a magnetic code area representing the unexpired value of the token, and means for updating the magnetic data

to represent the decremented value of each token after use, characterised in that each magnetic token is in accordance with any of Claims 1 to 8 and the transaction apparatus additionally includes means (24) for selectively magnetising unmagnetised regions (20) of each token to remove magnetic fuses (21) dependant on the decremented value of the token.

8. A system as in Claim 7, characterised in that the transaction apparatus (10) also includes means for rejecting any token (1) having less than a predetermined number of unmagnetised regions (20).

9. A system as in Claim 7 or 8, characterised in that each magnetic fuse (21) represents a predetermined fraction of the original value of the token (1) recorded in a read/write area (8) of the token, and the means (24) for selectively magnetising each unmagnetised region (20) is arranged to remove a magnetic fuse (21) whenever the value of the token is decreased by an amount equivalent to said predetermined fraction.

10. A system as in Claim 9, characterised in that each token (1) has ten magnetic fuses (21) each representing one tenth of the original value of the token.

11. A system as in Claim 9, characterised in that each magnetic fuse (21) represents a different fraction of the original value of the token (1).

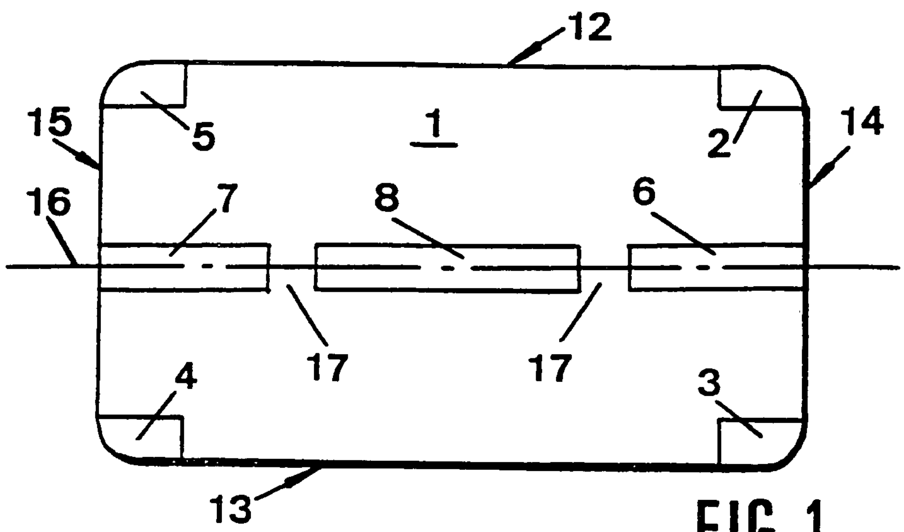

FIG.1

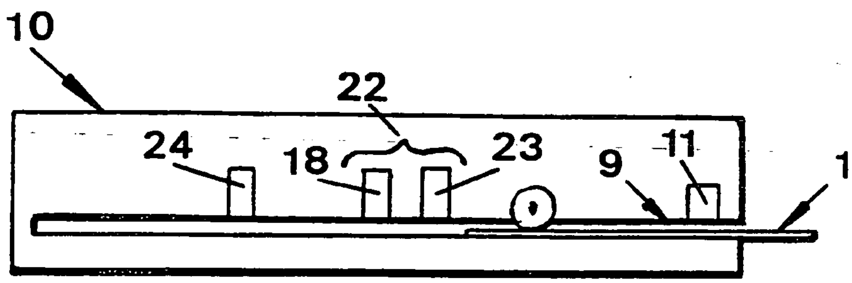

FIG.2

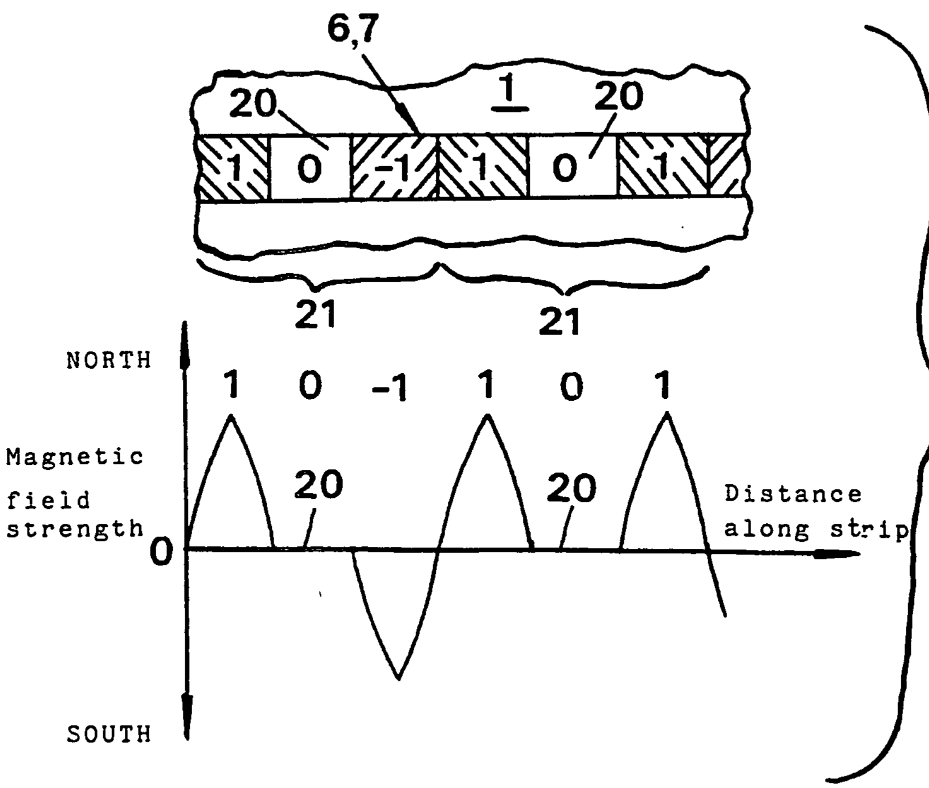

FIG.3

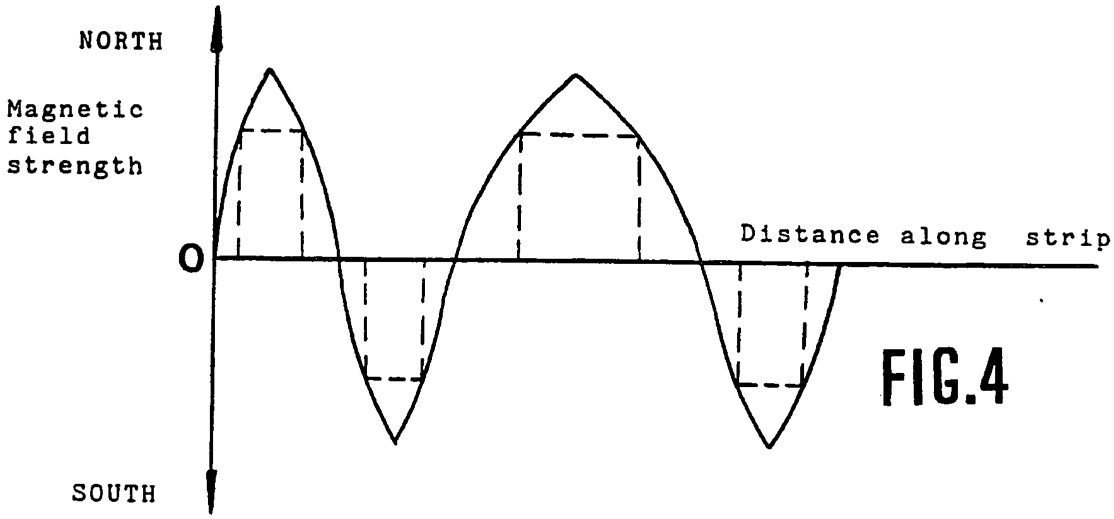
NORTH
Magnetic field strength
O
Distance along strip
SOUTH

FIG.4

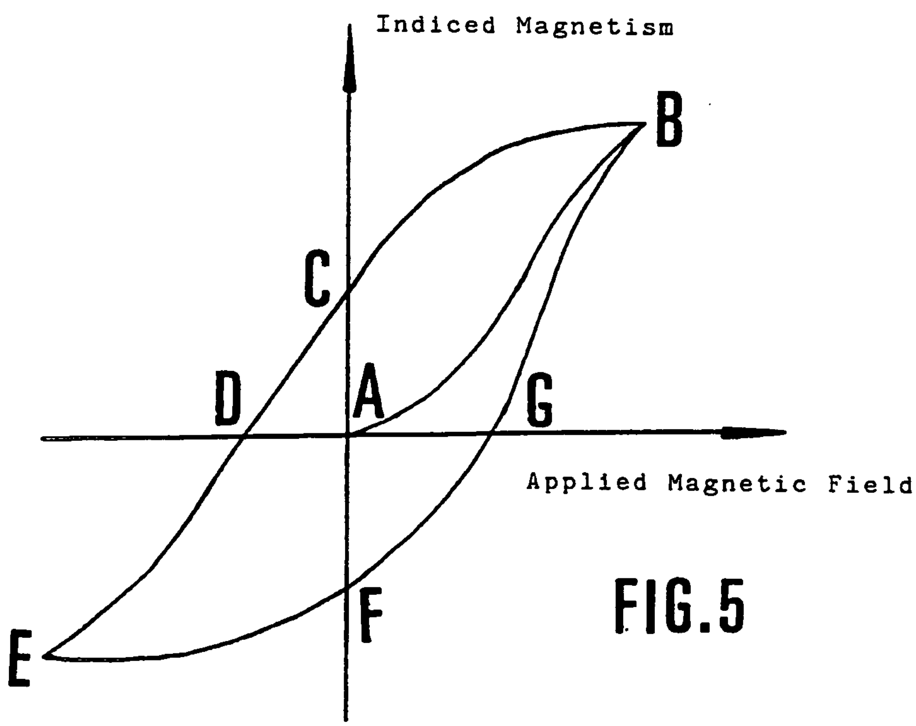
Indiced Magnetism
B
C
D
A
G
Applied Magnetic Field
E
F

FIG.5

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/01171

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G07F7/02; G06K19/12

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G07F ; G06K ; G07B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	EP,A,0 024 800 (EMI) 11 March 1981 see page 4, line 16 - page 7, line 11; figures 1A,1B ---	1-10
A	GB,A,2 027 965 (THE MARCONY COMPANY) 27 February 1980 see page 1, line 87 - line 122; figure 1 ---	1-4,7-10
A	US,A,4 228 348 (C.A. LEE) 14 October 1980 -----	

° Special categories of cited documents : [10]

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2

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20 OCTOBER 1992	03. 11. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	DAVID J.Y.H.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9201171 SA 61613

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0024800	11-03-81	None	
GB-A-2027965	27-02-80	DE-A- 2843786	27-03-80
US-A-4228348	14-10-80	GB-A- 1593377	15-07-81

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